CHAPTER TWELVE

MANUFACTURING SURVEYS AND REVIEWS

CONTENTS

MANUFACTURING SURVEYS AND REVIEWS

OBJECTIVES

The material in this chapter is directed toward describing the nature and purpose of the various manufacturing surveys which are required during the life of a defense program and the elements of planning and execution which have historically been viewed as critical to the successful attainment of survey objectives. The major focus within this chapter is on the Production Readiness Review (PRR), reflecting its importance within the milestone review process. It should be noted that the planning and procedural guidance provided for the PRR are also applicable to other reviews and surveys. In using the material for these purposes, it is necessary for the program management office (PMO) to adjust the procedures to reflect the differences in objectives, scope, breadth of coverage and depth of involvement.

INTRODUCTION

Manufacturing surveys are conducted to obtain some measure of the capability of defense contractors to perform the manufacturing tasks and to develop estimates of the production risk inherent in the design and the proposed manufacturing approaches. The areas of interest generally reflect analysis of the physical, managerial and financial capability of the contractors to accomplish the work required, especially when other demands may be placed upon the available production resources. Manufacturing reviews are conducted to focus on issues related to the adequacy of the manufacturing management systems, and the application of the systems to the specific product to be produced.

Survey Objectives

A survey may be conducted to identify and minimize the uncertainties inherent in acquisition of major or complex defense systems. Specific objectives of a survey may include:

- Substantiating program adequacy
- Selecting contractor sources
- Structuring contracts
- Supporting internal program decisions
- Supporting milestone decisions

TYPES OF SURVEYS

Manufacturing surveys can be divided into two broad categories; system centered and product centered. In most cases, the PMO will be involved with the product centered surveys since the PMO mission is to manage development and production of a specific system or product.

A manufacturing management system survey is concerned with the basic system which has been developed by a contractor for planning, executing and controlling the manufacturing function within the specific facility. Except when the Cost/Schedule Control Systems Criteria (C/SCSC) is applied on a contract, surveys such as these are most often accomplished by the designated Contract Administration Office (CAO) as a part of their continuing review and evaluation of contractor operations effectiveness. When C/SCSC is applied, the CAO provides one or more members to the C/SCSC Review Team and, after acceptance of the contractor's management system, the CAO provides continuous surveillance. The basic thrust behind the accomplishment of system surveys is the hypothesis that the success of a contractor on a specific program is strongly dependent upon the existence of a defined, well operating management system.

The specific system to be used by the contractor will be unique to that company's business objectives, size, product mix and operating style. The focus on these types of reviews should be on the capability of the management system to support effectively the current and planned levels of manufacturing operation. To make this determination, the review team needs to ensure that the system is structured, defined and communicated to the individuals within the company who are charged with making it work. It is also necessary to make a determination that the system is, in fact, functioning as it is described. A company often has an apparently well structured system which, unfortunately, is not used by its personnel. Where specific manufacturing management requirements such as C/SCSC or MIL-STD-1528, Production Management, are established within the contract, there is a need to determine contractor compliance with these requirements. For this type of system survey, the team is composed of both CAO and buying office personnel, but the basic thrust remains the same. Where these types of surveys have been accomplished, the program office should use the findings as an element of the manufacturing risk assessment and as an input to the evaluation of schedule attainability. Where management system weaknesses are defined, the program manager should consider ways to motivate the contractor to correct the problem.

Product Centered Surveys

A number of surveys (reviews) are accomplished on specific equipment or systems. Some of the more common ones are listed in Figure 12-1 and defined in Appendix B. In addition to these manufacturing based reviews, issues concerning design, producibility and manufacturing planning are integral parts of the continuing design review process and should be addressed at the reviews listed in Figure 12-2.

- PRODUCTION READINESS REVIEW (PRR)
- PRODUCIBILITY REVIEW
- PRODUCTION FEASIBILITY REVIEW
- PRE-AWARD SURVEY
- PRODUCTION CAPACITY REVIEW
- PRODUCTION PLAN REVIEW

Figure 12-1 Product-Centered Surveys

- SYSTEM REQUIREMENTS REVIEW (SRR)
- SYSTEM DESIGN REVIEW (SDR)
- PRELIMINARY DESIGN REVIEW (PDR)
- CRITICAL DESIGN REVIEW (CDR)
- FUNCTIONAL CONFIGURATION AUDIT (FCA)
- PHYSICAL CONFIGURATION AUDIT (PCA)

Figure 12-2 Design Reviews

MANAGING THE SURVEY AND REVIEW TASK

As was noted earlier in the chapter, a number of product centered surveys may be required during the acquisition of a specific system. These surveys are fundamentally similar in approach since they all seek to define industry's capability to produce proposed systems or to measure the manufacturing risk level inherent in specific programs. The primary differences in the procedures for accomplishing the surveys are driven by differences in the:

- Nature of the required output of the survey
- Depth of evaluation
- Breadth of
- Degree of design definition existing at the time of the survey
- Amount of completed manufacturing planning
- Existence of competition in the program.

To define the management approach to product oriented surveys, the focus will be on the production readiness review. This review has been a relatively high visibility requirement during the system acquisition process and is expected to retain significance in any service decision to initiate the manufacture of defense systems. The PRR procedures and techniques can be tailored for use in other reviews by making appropriate adjustments based upon the differences described previously.

PRODUCTION READINESS REVIEW

A Production Readiness Review (PRR) is a formal examination of a program to determine if the design is ready for production, if production engineering problems have been resolved, and if the producer has accomplished adequate planning for the production phase. Because adequacy is an imprecise issue, the degree of adequacy should be addressed within the context of the specific program, in terms of the risk levels that have been determined to be acceptable for that program. The production readiness review attempts to verify that the production design, planning and the associated preparations for producing the system have in fact progressed to the point where a manufacturing commitment can be made without incurring unacceptable risks of breaching the established thresholds of cost, schedule, performance or other criteria.

Obviously, there is no such thing as a risk-free program. The objective of the PRR is to measure the level of manufacturing risk. After measuring the risk, the next step is to identify actions that will resolve that risk. Two key issues should be noted: First, the extent of conformance with a model state of production readiness is related to the time at which the assessment is made. While it is possible to accomplish the PRR immediately prior to initiation of the Production Phase, so doing loses the opportunity to identify problems early and solve them prior to production start. A number of program offices have taken an incremental approach to PRR risk assessment by starting early in the development phase. The review is accomplished incrementally as the design evolves and the testing is accomplished. The PM office continually rolls the knowledge from those efforts into the assessment of readiness and the assessment of risk identification and resolution. The second issue is whether the assessment is in support of a limited release for manufacture or a full release. For full production release, a complete evaluation of system readiness, problem resolution, and adequacy of planning are needed. Where possible, the objective is to quantify the validating data.

INDICATORS OF PRODUCTION READINESS

A number of indicators have been identified by the DOD Product Engineering Services Office (PESO) which can be used to develop meaningful and measurable data concerning readiness of the product to enter production based on information that is normally required as a part of defense contracts. In the development of the indicators, the following factors should be considered:

1. Each system is made up of a number of factors which make it unique in terms of its problems, time scales, state of the art applications, budget restraints, and the necessity for change during development.

2. Data for the individual indicators should be available either in the program office or at the contractor's facility as

3. a result of normally imposed contractual requirements. No new data items should be required.

4. The indicators should be simple in concept and easily understood.

5. Because numerical values for the indicators are variable in time, trend data are considered to be of more value than point data.

Based on these considerations, hardware and software indicators listed in Figure 12-3 may be evaluated.

HARDWARE INDICATORS

- ENGINEERING CHANGE TRAFFIC
- RELIABILITY GROWTH PATTERNS
- YIELD RATES FOR SPECIAL MANUFACTURING PROCESSES
- YIELD RATES FOR TEST OPERATIONS
- SCRAP AND REWORK LEVELS
- LEVEL OF EFFORT ON NONCONFORMING MATERIALS
- OUT-OF-STATION WORK PERFORMED

SOFTWARE INDICATORS

- RATE OF DISCOVERY OF ERRORS
- RATE OF CHANGE OF REQUIREMENTS
- RATE OF CHANGE OF REVISION LEVEL
- PERCENT MEMORY AND SPEED CAPACITY UNCOMMITTED

Figure 12-3 Production Readiness Indicators

Data from current and past programs can be analyzed to develop basic trend patterns for each of these indicators. These patterns can then be used as a baseline for comparison with new programs and to identify areas which may represent problems or risks to success in production. An approach to use three of these indicators is described below to indicate the types of analyses required.

Engineering Change Traffic Profiles

Examination of the engineering change traffic profile can be revealing in terms of the design maturity of a system, as well as symptoms of specific problems in the areas of fabrication, inspection and test operations, subcontracted equipment, or in system specifications. When the number of engineering changes made is plotted against a time scale which includes the development cycle, a pattern such as that shown in Figure 12-4 will normally occur.

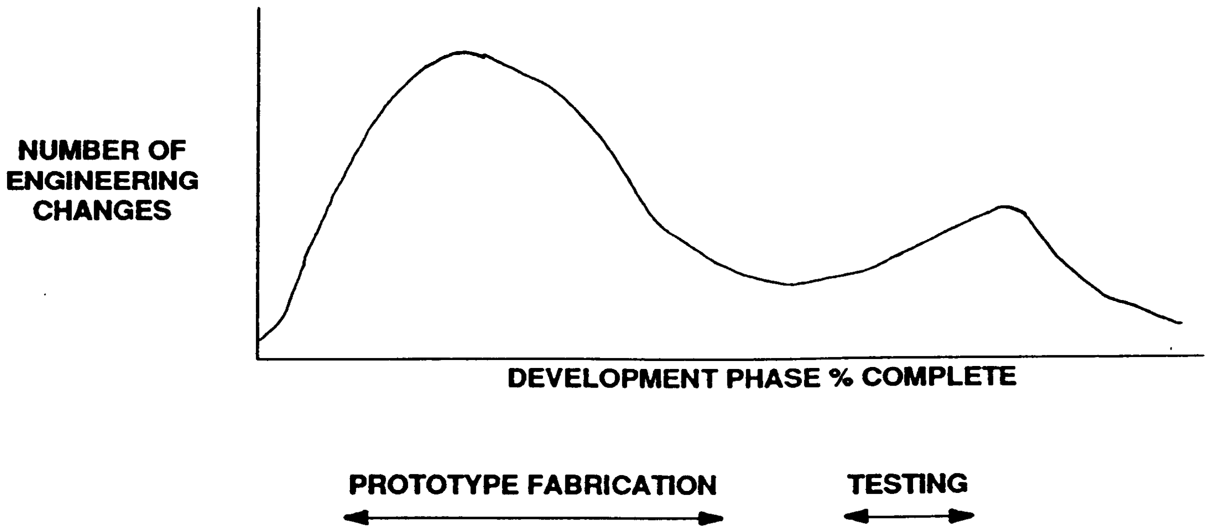

Figure 12-4 Projected Profile for Engineering Change Traffic

The number of changes starts at a zero point prior to the engineering release. As hardware fabrication is initiated, the number of changes increases to a maximum and should decline as engineering problems are resolved. At the completion of the prototype build, the number of changes should have followed a downward trend to a reasonable level. During prototype testing an increase in changes is noticed due to problems detected during the tests. The curve depicting the number of changes versus time should, again, follow a downward trend to a reasonable level, based on the program complexity.

Sustained levels of high change rate indicate a risk to cost, schedule, and/or performance. The appearance of an excessive number of changes at the completion of the prototype build should raise questions as to cause. It is obvious that both cost and schedule requirements would be extremely difficult to meet with an extended period of high change rate. Empirical data indicated that the shape of the engineering change traffic profile was of a similar shape for different kinds of systems including aircraft, electronic systems, tracked vehicles, and gun systems. The profile is sufficiently defined such that anomalies can be identified and investigated.

Yield Rates for Special Manufacturing Processes

A significant problem in meeting cost and schedule can result from low yield rates for manufacturing processes. Also, it would be unusual to find a new weapon system in which one or more "state of the art" manufacturing processes was not employed. Under the sponsorship of contractor R&D programs, and under the sponsorship of the Department of Defense (DOD) Manufacturing Technology Program, a significant number of special processes are under development at any given time. This constant development is necessary in order to reduce costs, increase performance, increase productivity, and advance the technology base. Examples of these special processes in the electronics field include methods for producing very high speed integrated circuits, multilayer printed circuit boards, and high density memory devices. Examples of these processes in the mechanical area include laser machining and joining, inertia welding, electrochemical and electrical discharge machining, vacuum plasma coating, and advanced methods for nondestructive testing.

Low yield rates for any of the special processes could have adverse effects on program cost and/or schedule and, therefore, could represent a program risk. The projected profile for special process yield rates is shown in Figure 12-5. As a new process is developed, the initial yield rate will be lower than the ultimate yield rate as the process variables are being defined and controlled. Normally, the major process variables are controlled first, leading to significant gains in the yield rate. In the later stages of development, the "fine tuning" of the process takes place. The "fine tuning" generally leads to smaller gains in yield. Because of this, the process yield approaches an ultimate yield value asymptotically.

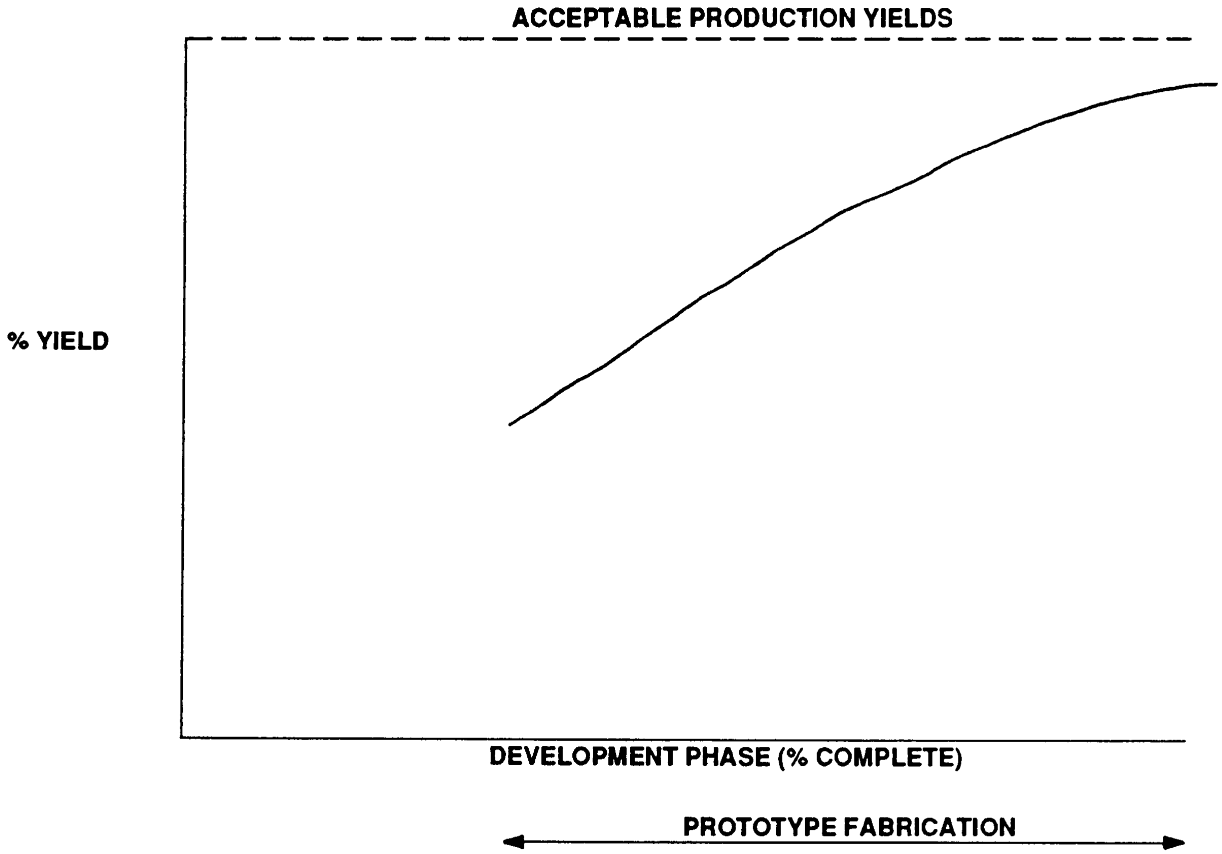

Figure 12-5 Projected Profile for Test/Process Yields

A plot of the process yield rate versus time should have the following characteristics:

1. A significant growth should be evident in the yield rate as a function of time or units processed.

2. The yield rate attained during the latest period should be acceptable in terms of dollar risk. It is difficult to place limits on the yield rate from a special process since the economic consequences represent a wide variation from one process to another. Restated, the cost of a reject from one process may represent a few cents, while a reject from another process may represent thousands of dollars.

Rate of Discovery of Software Errors

Experience on a number of software development programs indicates that the rate of discovery of errors appears to follow predictable patterns. Starting with coding checks and proceeding into each successive test phase, error discovery starts out at a relatively high level and follows a downward slope as problems are corrected. Errors typically are discovered during system integration testing. The contractor test team should show an initial high rate of error discovery which rapidly decreases as corrections are made. These relationships are shown in Figure 12-6.

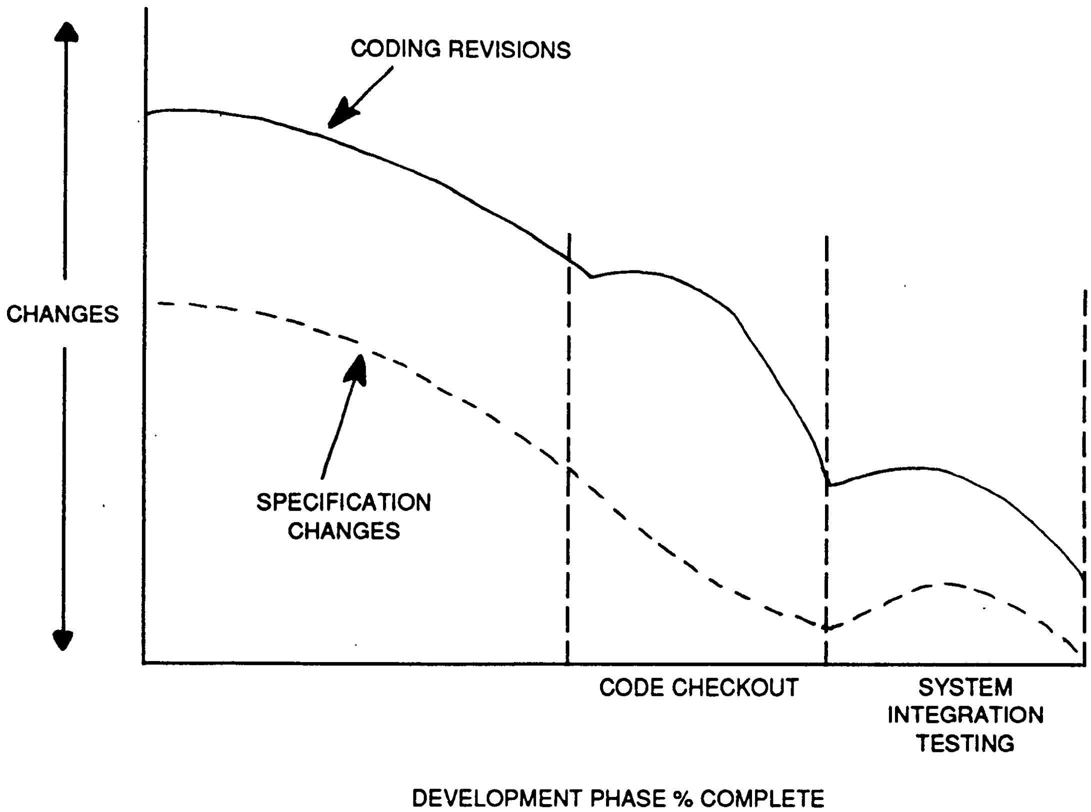

Figure 12-6 Projected Profile for Requirements Changes, Error Discovery, and Coding Revisions

Because of the ease of changing software, as opposed to hardware, software changes are frequently used to effect mission changes and to correct deficiencies in other subsystem areas. Excessive requirement changes in software can indicate potential hardware problems and a lack of maturity in the system requirements. Figure 12-6 depicts the normal behavior pattern for Engineering Change Orders issued against the Design Specification. This experience curve is analogous to the engineering traffic curve for hardware, in that it follows a downward trend, and then experiences smaller and smaller peaks as each successive level of testing is undertaken. Significant deviations from this general form should be identified as to cause. Engineering Change Orders issued against the Design Specification may cause the revision level of the software to be changed, and thus the rate of change of revision level can also be used as an indicator of program development maturity.

If a program is approaching the point where it is time to address readiness issues, it is worthwhile to review the current position of the DOD as to what elements describe the status of readiness for production. The PMO, when it goes to the Service Source Acquisition Review Council (S)SARC) or Defense Acquisition Board (DAB) for release for production, must cover production readiness findings in its advocacy paper. DOD may perform an independent assessment of the readiness of programs that go before the DAB. Also PESOs in the Services and at DOD are charged with the responsibility of independent assessments of production readiness, submitting information separately to the decision making organization. It is generally beneficial to have the DOD PESO and the Service PESO involved with planning and executing the PRR and with determining the method and style of presenting production readiness issues. That leads to the question, "How do we achieve the requirements for production readiness reviews?"

CONTRACTING FOR THE PRODUCTION READINESS REVIEW REQUIREMENT

Since there is a certain amount of necessary contractor cost associated with supporting a Production Readiness Review, it is important to assure that appropriate requirements are included in the Statement of Work (SOW) covering PRR support. The success of the PRR is dependent upon a proper environment being created through appropriate contract language. The specific SOW terms need to be tailored to reflect the program objectives, the funds available for accomplishing the PRR task, and the prime and subcontract structure of the program. The language should be as specific as possible to minimize future conflict in the understanding of the requirement. Whenever possible, the types of contractor preparation required for PRR team visits, the PRR team size, number of planned visits and their duration should be specified.

SURVEY ISSUES FOR PRODUCTION READINESS REVIEWS

In identifying the specific areas to be evaluated, the focus should be on those areas which could have the maximum impact on readiness. Developing this focus can be started with identification of the high value or critical items. In most cases, a large portion of the cost and risk is in a small percentage of the items. These are the items on which to focus effort. The review should explore the production implications of the design. Given the details of the design, how can it be built? What are the limitations on the productive processes? What process limits the production capacity? What kind of fabrication approaches can be used? What will it cost to do it? Given a pre-existing unit production cost goal and a breakdown of that goal through the work breakdown structure, the current subsystem and part estimates can be compared to the goals and an engineering trade-off study can be conducted. If the design is not acceptable from either a cost and/or performance standpoint, it will be necessary to go back and look at alternative designs. What design alternatives might yield the same or improved performance? The design needs to be evaluated in terms of the three basic parameters of cost, schedule and quality. (As used here, the quality of the design is the broader term including performance, reliability and maintainability.) After this evaluation, there is a need to define actions such as design changes or process changes. The design cannot be forced to meet the constraints of a specific contractor's production environment nor can the government force this production environment to meet a noncompatible design. Often trades must be made, so both the design and the production process selection must be somewhat flexible during the design evolution. The survey team should see evidence of contractor trade studies which compare alternative approaches to the fabrication and production tasks. The specific issues addressed during the product design evaluation are shown in Figure 12-7.

Design Simplicity
Standardized Parts
Early Design Confirmation
Use of Efficient, Proven Manufacturing Technology
Process Repeatability and Inspectability
Safe Work Environment
Lead Times
Critical Processes
Special Tooling
Personnel Skills
Minimum Design Change Activity
Availability

Figure 12-7 Product Design Evaluation Issues

ROLE OF THE CONTRACT ADMINISTRATION OFFICE

The Contract Administration Office (CAO) can make a significant contribution to most, if not all, of the manufacturing reviews and surveys which are accomplished during the life cycle of a system acquisition. With respect to one of these reviews, the preaward survey, the CAO is the action office for the assessment of contractor capability.

The CAO, as a result of its continuing involvement with the specific contractors, can make major contributions to the successful accomplishment of the PRR. Where the specific Service has plant cognizance, the CAO organization, Air Force Plant Representative Office (AFPRO), Navy Plant Representative Office (NAVPRO) or Army Plant Activity will normally have developed procedures for supporting the survey effort. For the purposes of this guide, the focus will be on the support available from the Defense Contract Administration Services (DCAS). This will provide a framework for cooperation similar to that which would be involved in a situation involving service plant cognizance.

With proper notice of the requirement for a PRR or other survey, the Program Manager can expect DCAS personnel to be on-site and ready to assist the survey team when it arrives. He can expect an in-briefing from the assigned DCAS engineer on the strengths and weaknesses of the contractor involved. The DCAS Engineers, Industrial Specialists and Quality Assurance Specialists will be prepared to answer questions pertaining to the topics listed in Figure 12-8.

Plant Resources/Facilities
- Adequacy for Rate
- Timely Acquisition/Installation
- Automated Production Techniques

Contractor Personnel
- Personnel Levels
- Skills Development/Training
- Certification

Production Engineering/Planning
- Schedule Compatibility
- Cost Reduction
- Alternative Capacities
- Configuration Management
- Handling of Engineering Changes
- Management Information System Adequacy

Materials/Purchased Parts
- Long Lead Items
- Procurement Plan
- Selection of Subcontractors
- Visibility of Subcontractors

Quality Assurance
- Integration with Production Planning Corrective Action

Contract Administration
- Attitudes
- Character
- Working Relationships

Figure 12-8 Contract Administration Office Expertise

In most cases, the personnel assigned to DCAS are highly trained and experienced professionals. They constitute a considerable body of technical expertise familiar with the capacity and capability of the contractors involved in acquisition programs. They represent a substantial resource to program managers which should be utilized to get the most effective use of our limited Defense Budget. In many cases, these resources can be used to offset the problems of finding sufficient numbers of qualified personnel at the PM or buying activity.

When utilizing CAO personnel, it is incumbent on the PM to provide to the CAO personnel an understanding of the specific objectives and risks inherent in the acquisition program. This will provide the necessary "program focus" to the review. It should also be noted that the CAO personnel can provide significant value in the post review time period. Since they continue in residence at the contractor's facility, they can make major contributions to the surveillance of status on action items and periodic reporting of contractor progress.